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AUTHOR Kommers, P. A. M.
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ABSTRACT

Hypermedia as a learning environment complements traditional instruction as it places the student at a higher level of control. Instead of "wait and see" what the teacher expects the student to learn next, hypermedia stimulates the student to become aware of his/her own cognitive needs and interests. This paper presents a combination of notions from "planning," "concept mapping," "communication," and "design methods" in order to make externalizing prior concepts, planning future learning sessions, and negotiating design approaches with peer mates via distance media more challenging and appealing to students. The student's design activity is examined while he/she designs a technical solution to the given problem specification. The following support systems are used in the design process: Fischer Technique (or Technical Logo) kit for the assembly of the mechanic/electronic sensing/control device; LOGO-based programming tool to control the Fischer Technique kit; a concept mapping program that can be run in concurrence with the LOGO system; and a communications facility to collaborate and negotiate with a peer student. Hypermedia and telematic facilities allow students to demonstrate, argue, and negotiate about alternative perspectives on the design task and subsequent solutions. An acceptable design is illustrated in one figure. (Contains 11 references.) (Author/MAS)

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Dr. P.A.M. Kommers
University of Twente
Faculty of Educational Technology
Box 217
7500 AE Enschede
The Netherlands

Office:	Tel	+31 53 893576 or +31 53 893611
	Fax	+31 53 356531
Private:	Tel	+31 53 336717
	Fax	+31 53 335715
Email:	TOKOMMERS@UTWENTE.NL	

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Paper proposal for the EARLI'95 symposium on "Learning with Hypermedia" in the domain "Learning and Technology".

Conceptual Design to Complement Hypermedia as Learning Tools.

Abstract:

Hypermedia as a learning environment complements traditional instruction as it places the student at a higher level of control. Instead of 'wait_and_see' what the teacher expects me to learn next, hypermedia stimulate the student to become aware of his/her own cognitive needs and interests. In this paper we will present the combination of notions from 'planning', 'concept mapping', 'communication' and 'design methods' in order to make it challenging and appealing to students to externalise prior concepts, plan coming learning sessions, and negotiate design approaches with peer mates via distance media.
The student's design activity will be examined while he/she designs a technical solution to the given problem specification. The next support facilities will be given:

- Fischer Technique (or Technical Lego) kit for the assembly of the mechanic/electronic sensing/control device.
- LOGO-based programming tool to control the Fischer Technique kit.
- A Concept Mapping program that can be run in concurrence with the LOGO system.
- A communications facility to collaborate and negotiate with a peer student. This connection allows a video-, audio and free text communication between the two students at different locations.

Hypermedia and telematic facilities allow students to demonstrate, argue and negotiate about alternative perspectives on the design task and subsequent solutions.

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Conceptual Design to Complement Hypermedia as Learning Tools.

Introduction

Cognitive learning tools have enabled us to think in a more creative way on the essence of learning, in particular the acquisition of knowledge and the development of learning strategies by the learner him/herself. The notion of 'constructionism' entails a subjectivistic view on learning goals, easily passing by the commonalties in students' prior knowledge and acquired learning styles. Rather than approaching the learning process as idiosyncratic and unique for any moment in a student's maturation, it seems to be desirable to focus and define a strategic level of task approach in the conceptual apprehension of new ideas at the learner. Cognitive support tools for learning can be categorised along three dimensions:

1. Prescriptive versus Exploratory
2. Explanative versus Simulative
3. Expository versus Conceptual

As media and communicative facilities emerge, we now have better opportunities to arrange and manage learning environments which allow the learner to explore, investigate and become acquainted with concepts underlying the new subject to be learned. This paper addresses the facilitation of conceptual development during learning, especially in CSCW situations. '*Just_in_Time Cooperation*' between students attacking design problems becomes possible as multimedia communication by Internet allows learners to find 'compatible' sparring partners in exploring underlying concepts in technical domains.

So far 'exploration' and 'learning by experiment' have been worked out in research studies making use of hypermedia and computer simulation programs. Concept mapping tools for learning have mainly been investigated as 'knowledge synthesisers' and 'navigational support systems for hypertext'. The two new areas in educational instrumentation 'Telematic Distance Cooperation - ' and 'Virtual Reality for learning' need additional learning and teaching approaches. Concept mapping may be appropriate to

- orient students
- articulate prior and final knowledge
- exchange views and ideas among students at a distance
- transfer learned knowledge between different topics and domains.

In order to benefit from the student's explicitly represented concept structures, here also a new learning approach is needed. To meet the need for planning, controlling and evaluating during a so-called 'constructionistic' learning process a more explicit model for the student's activities is needed. The process of 'instruction' in which the teaching entity takes primarily the planning, monitoring and control function, is complemented or even replaced by the student him/herself and gradually becomes a process of '**extruction**'. A student should be coached then to become ones own teacher. Like a teacher needs a period of planning, contemplation and design, students need also additional skills and attitudes to prepare themselves for effective learning. In the current research proposal the 'Design' approach is chosen as organising principle for students to anticipate to their learning. Design can be seen as a goal-driven, concept-oriented and flexible way of sketching a way to approach the (learning) task. Crucial for effective design is the student's learning from earlier experiences, and also the support of meta-learning based on peer conversations concerning a common task. Though the 'Design' approach for 'constructionistic' learning itself is supposed to be generic for many types of learning, in this research proposal has been chosen for a collaborative design task, to be solved by two or three students. A construction task like 'how to equip a robot so that it will orient in a new maze with remote sensing?' is given to a pair of students at remote locations. The primary goal to discover and explore technical principles is preceded, interrupted and complemented by individual concept mapping and negotiation between students about their concept maps. This process of exchanging and discussing conceptual approaches is meant to externalise the student's problem perception, but also to improve one's flexibility and readiness to accept a colleague's alternative perception as a valuable contribution. This paper describes the 'design' approach in learning. In order to investigate evolving mechanisms during the design, a collaborative task has been defined: It involves both the physical constellation of a control device and the creation of the software. The software to control the designed devices will be LOGO. This choice is based on good results with LOGO as quick prototyping environments and its availability for the interface of the Fischer Construction sets.

Planning, Problem Solving and Designing during Learning.

Media become more integrated both in learning and work settings. Teaching problem solving skills, cooperation, design and the integration of knowledge is part of the learning process itself, and should be an intrinsic element in a learning task. With the coming of massive and yet flexible information resources in learning settings as hypermedia

and Internet-based connections, a stronger appeal comes to the student's own responsibility and learning management skills. Constructionism is an attempt to let students create their own mental concepts and let them construct agglomerations of concepts from prior knowledge. However entropic mechanisms in the student's mind may lead to early misconceptions and fragmented abstractions. To take the challenge of an increased student autonomy while reducing negative effects of the constructionist approach, it becomes opportune to define procedures for planning, problem-solving and inter-student negotiation about concept structures.

Planning, problem solving and designing have in common that they urge the student to anticipate to coming learning events, based on general beliefs, past experience and content elements in the subject to be mastered. Bransford (1986) defined a general problem solving sequence with an acronym IDEAL, expressing the stages: Identify, Define, Explore, Act and Look. Planning is intimately linked to the problem solving aspect in learning as it is the first step to anticipate to new, sometimes overwhelming information that does not directly fit in the current conceptual state. Planning in respect to learning thus asks from the student to take alternative views on his prior knowledge and to prepare the most comfortable embedding of new concepts in his current imagination. Iran-Nejad (1990) suggested that learning complex information is not achieved simply through the enlargement of one's knowledge, but through the reconceptualization of internal knowledge. This idea is also present in De Lisi's (1990) view of the development of the twofold planning process at the learner:

- The awareness of a planning concept (representational component), embodying the notion of goals and subsequent actions to be achieved in order to achieve the objective as presented in the learning setting
- The organising aspect of planning (functional component), involving goal-directed behaviour, without conscious recognition of the actions that are necessary to achieve the goal.

As students become more mature, the representational component of plans become more prominent: Students master first how to perform a task, even before they comprehend what they are doing and why. Case (1992) has proposed that students need a clear understanding of their monitoring and planning process before they become adept at making judgements about what interactions or decisions are needed to deal with learning and problem solving. Case's model incorporates the iteration along 'orientation', 'acquisition' and 'application'. This takes place at different levels in the student's learning and development process: Introduction, establishment, consolidation and incorporation. The hypothesis to be investigated in the proposed research is that the instrumentation, explicitation and procedural embedding of the planning and monitoring functions adds necessary cognitive control to the student in constructionistic learning situations.

Conceptual Representation, - Change and -Design

In product design, the majority of efforts is expected to be in the refinement of shape and technical implementation. In order to **learn** basic principles, and make them flexible in the problem approach, it is crucial to allow the student to explore different ways and perspectives on a given functionality description. Ogborn (1990) examined how students understood entities like time, space, matter movement and energy using three aspects: "what is it like?", "what can it do?" and "what can be done to it?". The experiments indicated underlying student's notions such as *support* and *effort* in their common sense reasoning about motion, detection, control and equilibrium. Schematic representations proved to be effective to negotiate about primitive notions among students. Schemes are defined as sets of actions which constitute part of a way of acting on the world, or, arising out of actions, a partial way of looking at the world. Schematic Conceptual representations are generalised characterisations of schemes which allow students to transfer knowledge from one type of problem to another.

Planning, monitoring and controlling one's own learning process may not reduce the flexibility to change conceptual perception of the problem space. This is why special attention will be given in the aimed project to flexible concept representations that both allow conceptual shift, but at the same time stimulate the student to develop metacognition and the attitude to communicate intermediate stages with other students.

Based on earlier experiments with concept mapping in learning situations with hypermedia, we may expect to find typical preferences between different stages in design tasks. The concept map in Figure 1 shows a high level abstraction of locomotive mechanisms entailing relations as *space*, *time* and *move*. Attached to more concrete design tasks like the sensor/actor robot devices controlled by LOGO, schematic representations will contain physical entities like LDR (Light Dependant Resistor), NTC (Negative Temperature Coefficient), LED (Light Emitting Diode), micro switch, ultrasonar buzzer and -microphone, electro motors, lamp, potentiometer etc. The function of the concept map representation is to stimulate a more global view on the student's chosen direction of the control solution, and to make it easier to students to benefit from alternative problem approaches. We expect that depending on the design phase, the level of prior knowledge, and the stage in communication, there is a need for a specific concept mapping tool, with its own entities, symbols and procedures. Current concept mapping tools to accompany learning are: SemNet (Fisher, 1991), Learning Tool (Kozma, 1991) and Textvision (2D and 3D) (Kommers, 1991).

The paper presentation will present initial experiments with the design task in order to establish specific preferences for one or combinations of the mentioned concept mapping tools.

Conceptual Change

Learning is mediated by thinking (mental processes). Thinking is activated by learning activities, and learning activities are mediated by instructional interventions, including technologies. [...] The role of delivery technologies should be to display thinking tools: tools that facilitate thinking processes (Jonassen, 1991). Deeper information processing results from activating appropriate schemata, using them to interpret new information, assimilating new information back into the schemata, reorganising them in light of the newly interpreted information, and then using those newly aggrandised schemata to explain, interpret, or infer new knowledge (Norman et al, 1978). Both these authors stress the importance of mental activity for learning, the learner needs to perform such operations on the newly acquired information that will relate this to prior knowledge. Prior knowledge may be incomplete or even contradictory to the information to be learned (misconceptions). In this case conflicts will occur between the old and the new information.

Experimental results by Howe (1991) support the idea of the need for a period of private "digestion" or reflection, even when the occasion for learning has been a social one. She showed that pairs of children discussing a problem in elementary physics generally promoted conceptual development in both (Draper, 1990). That not the extra time on the task explained these results is explained by the Levels of Processing Theory (Craik and Lockhart, 1972). In a long series of experiments Craik and Tulving (1975) found that time to encode was not the critical factor for memorisation tasks. A complex but shallow task will take longer to perform but will yield lower memory scores than an easy but deeper processing task.

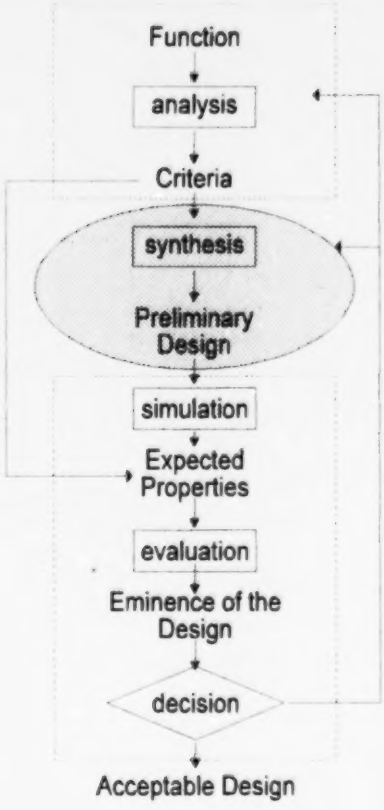
Relating to the control task cases it is important to take note of the enactment-effect (Cohen, 1981). The enactment-effect may be paraphrased to "people remember what they did, more than what they read, heard or thought." The building and testing give ample opportunity to do things, and to associate the related theory with these enactments.

Concept Mapping

Concept mapping is a technique to represent mental schemata and the structure of information. Making mental schemata and information structures explicit in such maps allows evaluation of these structures. Making comparisons, calculating measures, logical analysis are facilitated by explicit concept maps. Concept mapping can be categorised as a cognitive tool, it may be implemented in computer software. Cognitive tools are based upon a constructivist epistemology. The goals and design of constructivism differ from previous technological innovations. Traditional technologies such as programmed instruction and techniques such as instructional design are objectivistic. That is, their intention is to transmit objective knowledge. [...] Cognitive tools are constructivistic because they actively engage learners in creation of knowledge that reflects their comprehension and conception of the information rather than focusing on the presentation of objective knowledge. Cognitive tools are learner controlled, not teacher or technology-driven. Cognitive tools are not designed to reduce information processing, that is, make a task necessarily easier, as has been the goal of instructional design and most instructional technologies. [...] Rather cognitive tools provide an environment and vehicle that often requires learners to think harder about the subject domain being studied while generating thoughts that would be difficult without the tool. (Jonassen, 1991)

Design as a Learning Activity

Learning by designing is common whereas students are trained to become a designer. From a constructionistic point of view design can be seen as an inherent element in the acquisition and operationalisation of conceptual knowledge. The stage of *Synthesis* and *Preliminary Design* is crucial to learning as it provokes the student to chose a perspective on the posed problem, and to chose a direction for the solution. It is the stage where prior concepts play a role, and fragmented knowledge is detrimental for an effective solution. Designing as a learning method needs a closer examination. From earlier experiments (Jungck & Calley, 1986) have argued that 'designing as a style of teaching' in a genetics practicum is a post-Socratic Pedagogy, because the tools that are used creates an environment in which the teacher has no more idea than the students about what an answer or optimal strategy might be. .... the Student and Teacher swim side-by-side , navigating their study through uncertain waters.



Besides the instrumentational and instructional questions to be answered, it also clear that the curricular impact of the 'Design' approach will become evident in several years.

Cognitive Collaboration

Earlier the effect of discussion was mentioned as a way to stimulate thinking in the individual. But there is more to cognitive cooperation than just to have somebody to talk to and use to express your thoughts for. The other may influence the direction of the discussion and introduce new elements, such as points-of-view or examples; Nijhof & Kommers (1984). This may provide the learner with new opportunities to form cognitive links, or direct the learner to pay attention to neglected parts of the subject domain. It may also distract.

As stated before concept mapping may serve as a tool to make conceptual structures explicit, so that they may be discussed. Using co-operative concept mapping in design situations before making design decisions could conceivably lead to more alternatives being considered, and therefore lead to better decisions. This more thorough decision making would require, in terms of the Levels of Processing theory, deeper processing and therefore result in more lasting memorisation. Where design is used as in a learning by example approach, as suggested in this proposal, these effects should be observable.

At the level of dyads, students are requested to exchange their problem perception and subsequent solutions in concept maps. The actual performance of the chosen approach can then be done in the Fischer Technique Kit and the adjacent LOGO system.

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